

Michigan Department of Agriculture  
Groundwater Monitoring Program  
Domestic Supply Well  
Baseline Study Report

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## EXECUTIVE SUMMARY

The mission of the Michigan Department of Agriculture (MDA) Groundwater Monitoring Program is to determine the nature and extent of pesticide and nitrogen fertilizer contamination in Michigan's groundwater, to reduce the potential for negative health impacts associated with the use of low-quality groundwater, and to use the information gathered to improve communication about the risks to groundwater resources associated with different land-use activities. Over 2.5 million residents, 27.3 percent of Michigan's population, rely on domestic wells for their water supply (1990 U.S. Census).

The MDA groundwater monitoring program conducted a study of domestic well water quality between 1997 and 2000. It provides statistically meaningful estimates of domestic well water quality in rural areas of the state. The estimates apply to wells serving 83.5% of Michigan residents using domestic wells. Estimates for domestic supply wells in urban/suburban areas, serving the remaining 16.5% of Michigan residents using domestic wells, could not be made due to the nature of the study.

Samples from 391 wells selected at random were tested at the Michigan Department of Environmental Quality Drinking Water Laboratory for 75 pesticides, 66 volatile organic compounds, nitrite, and nitrate. The results have been weighted to correct for differences between the number of wells in the sample from each sub-population, and the number of wells in the state used by each sub-population. Detection frequencies are a function of detection limits, analytical methods, and the products detectable by the analyses used, other factors being equal. The results are summarized in the table below.

Parameter	Concentration	Estimated Frequency		
		Rural Non-Farm	Farm	All Rural
Nitrate-N	> MCL	< 1.7%	3.9%; 2.0% - 7.7%	< 1.9%
	> 20% MCL	9.2% ± 4.3%	12.7% ± 4.6%	9.3% ± 4.3%
	No impact observed	90.8% ± 4.3%	83.3% ± 5.1%	90.5% ± 4.3%
Pesticides (Listed in report Appendix A)	> MCL	< 1.7%	< 1.5%	< 1.7%
	> 20% MCL	< 1.7%	< 1.5%	< 1.7%
	Detected	< 1.7%	0.5%; 0.1% -2.7%	< 1.75%
	Not detected	> 98.3%	> 97.6%	> 98.25%
Volatile Organics (Listed in report Appendix A)	> MCL	< 1.8%	< 1.5%	< 1.8%
	> 20% MCL	< 1.8%	1.5%; 0.5%-4.5%	< 1.9%
	Detected	7.2% ± 3.9%	5.5% ± 3.2%	7.1% ± 3.9%
	Not detected	92.8% ± 3.9%	93.0% ± 3.5%	92.8% ± 3.9%

MCL Maximum Contaminant Level. Public water supplies must keep contaminant levels below the MCL. Domestic supply wells are *not* public water supplies.

Based on the results, it's estimated that *less than* 1.9 percent of all rural domestic wells in the state have nitrate-N levels above the public water supply Maximum Contaminant Level (MCL) of 10 ppm. Rural domestic wells include both farm and rural non-farm wells. The lack of detections of wells above 10 ppm nitrate-N in the rural non-farm group prevents a closer estimate. It's estimated that 3.9 percent of domestic wells on Michigan farms have nitrate-N levels of 10 ppm or higher, with a 95% confidence interval from 2.0% to 7.7%. No estimates of the frequency of wells with nitrate-N above 10 ppm were possible for urban/suburban wells, due to the lack of detections and the low number of wells sampled.

Approximately 9.3 percent of Michigan rural domestic wells,  $\pm 4.3$  percent, have been impacted by human-related nitrate sources, shown by nitrate-N levels between 2 and 9.9 ppm. Farm wells are somewhat more likely to have nitrate-N levels above 5 ppm than are rural non-farm wells ( $p=0.078$ ). The study indicates that 90.5 percent of the state's rural domestic wells,  $\pm 4.3$  percent, have nitrate-N levels lower than 2 ppm, the threshold for nitrate-N levels associated with human-related impacts.

One known pesticide, atrazine, was detected in one well, at a level of 0.2 parts-per-billion (ppb), 6.7 percent of the public water supply MCL. This represents 0.5 percent of the farm domestic wells sampled, with a 95 percent confidence interval of 0.1 - 2.7 percent. The percentage of all rural domestic wells with a detectable level of one or more of the pesticides covered in this study is estimated to be *less than* 1.75 percent. Because only 12 urban/suburban wells were sampled, no meaningful estimate of the pesticide contamination frequency for this subgroup is possible.

Volatile organic compounds (VOCs) are estimated to occur in 7.1 percent,  $\pm 3.9\%$ , of rural domestic wells in Michigan based on this study. Fifteen different VOCs were detected, including products associated with well construction, maintenance, and disinfection; solvents associated with dry cleaning and/or metal degreasing; fuel components; and miscellaneous VOCs. One VOC, 1,2-dichloroethane, detected in one well, has been used both as a solvent and in soil fumigants. There was insufficient information to determine the source of this product. Tetrachloroethylene, also known as perchloroethylene or "perc", was detected in one well at a level of 2.7 ppb, equivalent to 54 percent of its MCL. Other than some nitrate detections, this was the highest concentration relative to the MCL found in this study. Other VOCs detected included carbon disulfide, carbon tetrachloride, chlorodifluoromethane, and chlorobenzene.

Methyl-*tert*-butyl ether (MTBE), a gasoline additive, was detected in one well at a level of 10 ppb. This falls in the range of 25 to 50 percent of the MCL, depending on where the U.S. EPA establishes the final MCL for MTBE.

It appears that contamination of rural domestic wells by VOCs is more common than

pesticide contamination. The most likely VOC contaminants are those associated with well construction, maintenance, and disinfection (trihalomethanes and tetrahydrofuran); and with metal degreasing and dry-cleaning (chlorinated ethanes and ethylenes).

Of the compounds covered by this study, nitrate is the one most likely to be detected at a level above the public water supply MCL. Infants under the age of six months are most at risk from high nitrate levels, which can lead to a condition called *methemoglobinemia*. This condition reduces the capacity of infants' red blood cells to carry oxygen, and acute cases can be fatal.

Recommendations from the study are to continue monitoring domestic wells. Researchers and agencies must be aware of emerging monitoring issues, such as the presence of pesticide metabolites and degradates, contamination from pharmaceutical and veterinary products, and new toxicological, epidemiological, and fate and transport data showing changes in groundwater contamination risks.

The benefit/cost ratio of groundwater monitoring may be optimized by combining focused and statistical groundwater monitoring in the context of information needs. It's important to evaluate the water quality of urban/suburban domestic wells, given that over 400,000 Michigan residents rely on them. The MDA Groundwater Monitoring Program will be sampling urban/suburban domestic wells in FY 2001 and beyond to accomplish this goal.

There are many opportunities for cooperation in groundwater monitoring between federal, state, local, business, and non-profit organizations. Overcoming institutional inertia is the key to increasing cooperation in this discipline and reaping its rewards.

## APPENDIX A: ANALYTES INCLUDED IN MDA BASELINE STUDY LABORATORY ANALYSES



## WATER TESTING ANALYTES AND DETECTION LIMITS: 1997 SEASON

Tables 1-3 list the general chemistry, pesticide, and volatile organic compound (VOC) chemicals that are included in the Michigan Department of Public Health (MDPH) analyses of MDA water supply samples. Analyte detection limits are included.

Table 1. General Chemistry Analyte Detection Limits and Levels of Concern, from MDPH Lab "Interpretation of Common Tests."					
Analyte	Detection Limit (ppm)	Excellent (ppm)	Satisfactory (ppm)	Objectionable (ppm)	Related Problems
Chloride	2	nd <sup>1</sup> -20	20-250	> 250	Taste and Corrosion
Fluoride	0.1	0.3.-1.7	1.7-4.0	> 4.0	Lower levels beneficial in reducing tooth decay. Mottling of teeth at high levels.
Hardness as CaCO <sub>3</sub>	10	25-100	100-250	> 250 or < 25	Scaling of water fixtures, laundry problems, water spotting, discoloration at high levels. Corrosion at low levels.
Iron	0.1	nd-0.20	0.2-0.5	> 0.5	Staining, turbidity, taste, color, and odor.
Nitrate as Nitrogen	0.2	nd	nd-5.0	> 10	Levels greater than 10 ppm are a health hazard for infants less than one year of age. Levels greater than 5 ppm generally indicate some wellhead vulnerability.
Nitrite as Nitrogen	0.02	nd-0.2	0.2-1.0	> 1.0	Levels greater than 1.0 ppm are an established health hazard. Levels greater than 0.2 generally indicate some well vulnerability.
Sodium	2	nd-20	20-250	> 250	Values related to taste and corrosion. Persons on restricted salt diets should notify their physician of their water supply sodium content.
Sulfate	2	nd-20	20-400	> 400	Odor problems. Higher levels may have laxative effect.
<sup>1</sup> non-detect, compound not in water supply or present at a concentration lower than the detection limit.					
" > " = "greater than"; " < " = "less than."					

Table 2. Pesticide Analytes and detection limits <sup>1</sup>			
Analyte	Detection Limit (ppb) <sup>3</sup>	Analyte	Detection Limit (ppb) <sup>3</sup>
Acifluorfen	2	Eptam	1
Alachlor	0.2	Fluometuron	1
Aldicarb	0.5	3-Hydroxycarbofuran	0.2
Aldicarb Sulfone	0.5	Hexazinone	3
Aldicarb Sulfoxide	0.5	Linuron	1
Ametryn	1	Methiocarb	0.2
Atrazine	0.1	Methomyl	0.2
Barban	5	Metolachlor	1
Baygon (Propoxur)	0.2	Metribuzin	1
Bentazon	2	Neburon	1
Butachlor	2	Oxamyl	2
Butylate	2	Pentachlorophenol	0.06
Carbaryl	0.2	Picloram	2
Carbofuran	0.5	Prometon	1
Carboxin	2	Pronamide	1
Cyanazine	1	Propachlor	3
Cycloate	2	Propanil	2
Cyprazine	1	Propazine	1
2,4-D	2	Propham	5
Dalapon	20	Simazine	0.1
Dicamba	2	2,4,5-T	1
Dinoseb	0.3	2,4,5-TP (Silvex)	0.3
Diphenamid	1	Tebuthiuron	5
Diuron	1	Trifluralin	1
<sup>1</sup> Detection Limit: The lowest concentration detectable by the lab.			
<sup>2</sup> (ppm): Parts-per-million, equivalent to milligrams-per-liter (mg/l)			
<sup>3</sup> (ppb): Parts-per-billion, equivalent to micrograms-per-liter (µg/l)			

# WATER TESTING ANALYTES AND DETECTION LIMITS: FY 1997 SEASON

Table 3. Volatile Organic Compound Analytes and Detection Limits <sup>1</sup>			
Analyte	Detection Limit (ppb) <sup>3</sup>	Analyte	Detection Limit (ppb) <sup>3</sup>
Benzene	0.2	Dichloropropene (1,3-trans)	0.5
Bromobenzene	0.5	Ethylbenzene	0.2
Bromochloromethane	0.5	Dibromomethane (1,2) (EDB)	0.5
Bromoform (THM)	0.2	Fluorotrichloromethane	1
Bromomethane	20	Hexachlorobutadiene	0.5
Butylbenzene-Norm	0.5	Hexachloroethane	0.5
Butylbenzene-Sec	0.5	Isopropylbenzene	0.5
Butylbenzene-Tert	0.5	Isopropyltoluene-p	0.5
Carbon Tetrachloride	0.2	Methyl Ethyl Ketone	20
Chlorobenzene	0.2	Methyl Isobutyl Ketone	20
Chlorodibromomethane (THM)	0.2	Methyl Tert-Butyl Ether (MTBE)	1
Chloroethane	20	Methylene Chloride	0.3
Chloroform (THM)	0.2	Naphthalene	1
Chloromethane	50	Propylbenzene-Norm	0.5
Chlorotoluene (Combined)	0.5	Styrene	0.5
Dibromo-3-chloropropane (1,2)	2.5	Tetrachloroethane (1,1,1,2)	0.5
Dibromomethane	0.5	Tetrachloroethane (1,1,2,2)	0.5
Dichlorobenzene-m	0.2	Tetrachloroethylene	0.2
Dichlorobenzene-o	0.5	Tetrahydrofuran	5
Dichlorobenzene-p	0.2	Toluene	0.2
Dichlorobromomethane	0.2	Total Trihalomethanes	0.2
Dichlorobutane (1,4)	0.5	Trichlorobenzene (1,2,3)	0.5
Dichlorodifluoromethane	1	Trichlorobenzene (1,2,4)	0.2
Dichloroethane (1,1)	0.5	Trichloroethane (1,1,1)	0.2
Dichloroethane (1,2)	0.2	Trichloroethane (1,1,2)	0.4
Dichloroethylene (1,1)	0.2	Trichloroethylene	0.2
Dichloroethylene (1,2-cis)	0.2	Trichloropropane (1,2,3)	0.5
Dichloroethylene (1,2-trans)	0.2	Trimethylbenzene (1,2,4)	0.5
Dichloropropane (1,2) <sup>4</sup>	0.2	Trimethylbenzene (1,3,5)	0.5
Dichloropropane (1,3)	1	Vinyl Chloride	0.3
Dichloropropane (2,2)	1	Xylene- m & p	0.5
Dichloropropene (1,1)	0.5	Xylene- o	0.5
Dichloropropene (1,3-cis)	0.5	Xylene (Total)	0.5

<sup>1</sup> Detection Limit: The lowest concentration detectable by the lab.

<sup>2</sup> (ppm): Parts-per-million, equivalent to milligrams-per-liter (mg/l) .

<sup>3</sup> (ppb): Parts-per-billion, equivalent to micrograms-per-liter (µg/l).

<sup>4</sup> 1,2-dichloropropane has been used as a pesticide.

*All water analyses performed by the Michigan Department of Environmental Quality Drinking Water Laboratory (formerly the Michigan Department of Public Health Drinking Water Laboratory), Lansing, Michigan.*

Pesticide Analytes, Scans, and Detection Limits for MDA Samples, 1998 - 2000 Season			Pesticide Analytes, Scans, and Detection Limits for MDA Samples, 1998 - 2000 Season		
Analyte	Scan	* Detection Limit (ppb)	Analyte	Scan	* Detection Limit (ppb)
2,4-D	XHB	2	Hexachlorocyclohexane ( $\beta$ -BHC)	XPT	1
2,4,5-T	XHB	1	Hexachlorocyclohexane ( $\Delta$ -BHC)	XPT	1
2,4,5-TP (Silvex)	XHB	0.3	Chlordane, alpha	XPT	0.2
Acifluorfen	XHB	4	Chlordane, gamma	XPT	0.2
Bentazon	XHB	2	DDD,4,4'-	XPT	1
Dicamba	XHB	2	DDE,4,4'-	XPT	1
Dinoseb	XHB	0.3	DDT,4,4'-	XPT	1
Pentachlorophenol	XHB	0.08	Endosulfan, alpha	XPT	1
Picloram	XHB	2	Endosulfan,beta	XPT	1
			Endrin aldehyde	XPT	1
3-hydroxycarbofuran	XLP	0.2	Heptachlor	XPT	0.08
Aldicarb	XLP	1	Heptachlor epoxide	XPT	0.04
Aldicarb Sulfone	XLP	1	Hexachlorobenzene	XPT	0.1
Aldicarb Sulfoxide	XLP	1	Hexachlorocyclopentadiene	XPT	0.2
Baygon (Propoxur)	XLP	0.2	Octachlorocyclopentadiene	XPT	1
Carbaryl	XLP	0.2	Polybrominated biphenyls	XPT	1
Carbofuran	XLP	1	PCB (Aroclor 1016)	XPT	0.2
Methiocarb	XLP	0.2	PCB (Aroclor 1221)	XPT	0.2
Methomyl	XLP	0.2	PCB (Aroclor 1232)	XPT	0.2
Oxamyl	XLP	2	PCB (Aroclor 1242)	XPT	0.2
			PCB (Aroclor 1248)	XPT	0.2
Alachlor	XPT	0.2	PCB (Aroclor 1254)	XPT	0.2
Ametryn	XPT	1	PCB (Aroclor 1260)	XPT	0.2
Atrazine	XPT	0.2	Dieldrin	XPT	1
Butachlor	XPT	2	Toxaphene	XPT	2
Butylate	XPT	2	Bromacil	XPT	2
Carboxin	XPT	2	Chlorothalonil	XPT	1
Cyanazine	XPT	1	Dacthal	XPT	1
Cycloate	XPT	2	Terbacil	XPT	2
Cyprazine	XPT	1			
Diphenamid	XPT	1	Benzene	XVO	0.2
Eptam	XPT	1	Bromobenzene	XVO	0.5
Hexazinone	XPT	3	Bromochloromethane	XVO	0.5
Metolachlor	XPT	1	Bromoform (THM)	XVO	0.4
Metribuzin	XPT	1	Bromomethane	XVO	20
Prometon	XPT	1	Butylbenzene-Norm	XVO	0.5
Pronamide	XPT	1	Butylbenzene-Sec	XVO	0.5
Propachlor	XPT	3	Butylbenzene-Tert	XVO	0.5
Propazine	XPT	1	Carbon Tetrachloride	XVO	0.4
Simazine	XPT	0.2	Chlorobenzene	XVO	0.5
Tebuthiuron	XPT	5	Chlorodibromomethane (THM)	XVO	0.4
Trifluralin	XPT	1	Chloroethane	XVO	20
Endrin	XPT	0.05	Chloroform (THM)	XVO	0.4
Lindane (gamma-BHC)	XPT	0.04	Chloromethane	XVO	50
Methoxychlor	XPT	0.2	Chlorotoluene (Combined)	XVO	0.5
Aldrin	XPT	1	Dibromo-3-chloropropane (1,2)	XVO	2.5
Hexachlorocyclohexane ( $\alpha$ -BHC)	XPT	1	Dibromomethane	XVO	0.5

\* Detection limit is Practical Quantitation Limit. "Not Detected" assures levels below this value. If testing response indicates the confirmed presence of a compound below this value, the lab may report by comment (e.g., "Trace").

ppb: Parts-per-billion, equivalent to micrograms-per-liter ( $\mu\text{g/l}$ )

ppm: Parts-per-million, equivalent to milligrams-per-liter ( $\text{mg/l}$ )

Pesticide Analytes, Scans, and Detection Limits for MDA Samples, 1998 - 2000 Season			Pesticide Analytes, Scans, and Detection Limits for MDA Samples, 1998 - 2000 Season		
Analyte	Scan	* Detection Limit (ppb)	Analyte	Scan	* Detection Limit (ppb)
Dibromoethane (1,2) (EDB)	XVO	0.5	Methyl Isobutyl Ketone	XVO	20
Dichlorobenzene-m (1,3)	XVO	0.4	Methyl Tert-Butyl Ether (MTBE)	XVO	1
Dichlorobenzene-o (1,2)	XVO	0.5	Methylene Chloride	XVO	0.6
Dichlorobenzene-p (1,4)	XVO	0.4	Naphthalene	XVO	1
Dichlorobromomethane (THM)	XVO	0.4	Propylbenzene-Norm	XVO	0.5
Dichlorobutane (1,4)	XVO	0.5	Styrene	XVO	0.5
Dichlorodifluoromethane	XVO	1	Tetrachloroethane (1,1,1,2)	XVO	0.5
Dichloroethane (1,1)	XVO	0.5	Tetrachloroethane (1,1,2,2)	XVO	0.5
Dichloroethane (1,2)	XVO	0.5	Tetrachloroethylene	XVO	0.4
Dichloroethylene (1,1)	XVO	0.5	Tetrahydrofuran	XVO	5
Dichloroethylene (1,2-cis)	XVO	0.4	Toluene	XVO	0.5
Dichloroethylene (1,2-trans)	XVO	0.4	Total Trihalomethanes	XVO	0.4
Dichloropropane (1,2)	XVO	0.4	Trichlorobenzene (1,2,3)	XVO	0.5
Dichloropropane (1,3)	XVO	1	Trichlorobenzene (1,2,4)	XVO	0.5
Dichloropropane (2,2)	XVO	1	Trichloroethane (1,1,1)	XVO	0.4
Dichloropropene (1,1)	XVO	0.5	Trichloroethane (1,1,2)	XVO	0.5
Dichloropropene (1,3-cis)	XVO	0.5	Trichloroethylene	XVO	0.4
Dichloropropene (1,3-trans)	XVO	0.5	Trichloropropane (1,2,3)	XVO	0.5
Ethylbenzene	XVO	0.5	Trimethylbenzene (1,2,4)	XVO	0.5
Fluorotrichloromethane	XVO	1	Trimethylbenzene (1,3,5)	XVO	0.5
Hexachlorobutadiene	XVO	0.5	Vinyl Chloride	XVO	0.5
Hexachloroethane	XVO	0.5	Xylene- m & p	XVO	0.5
Isopropylbenzene	XVO	0.5	Xylene- o	XVO	0.5
Isopropyltoluene-p	XVO	0.5	Xylene (Total)	XVO	0.5
Methyl Ethyl Ketone	XVO	20			
Analyte	Scan	* Detection Limit (ppm)			
Chloride	R	4			
Fluoride	R	0.1			
Hardness as CaCO3	R	10			
Iron	R	0.1			
Nitrate as Nitrogen	R	0.4			
Nitrite as Nitrogen	R	0.05			
Sodium	R	5			
Sulfate	R	5			
Detection limit is Practical Quantitation Limit. "Not Detected" assures levels below this value. If testing response indicates the confirmed presence of a compound below this value, the lab may report by comment (e.g., "Trace").					
ppb: Parts-per-billion, equivalent to micrograms-per-liter (µg/l)					
ppm: Parts-per-million, equivalent to milligrams-per-liter (mg/l)					